

Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS):

next planned mission of the NASA Tropospheric Chemistry Program



**ARCTAS to be conducted in spring and summer 2008 (two phases)
as part of the POLARCAT program during the International Polar Year (IPY)**

ARCTAS white paper available: D.J. Jacob (lead), W.H. Brune, B. Cairns ,
K. Chance, J. H. Crawford, J. E. Dibb, J.C. Gille, R. Kahn , Q. Li, W. McMillan,
B. Pierce, L.A. Remer, P.B. Russell, H.B. Singh, C.R. Trepte, J. Worden

URGENT NEED TO BETTER UNDERSTAND ARCTIC ATMOSPHERIC COMPOSITION AND CLIMATE



ARCTIC IS A BEACON OF GLOBAL CHANGE

- Rapid warming over past decades
- Receptor of mid-latitudes pollution – arctic haze, ozone build-up, accumulation of persistent pollutants
- Large and increasing influence from boreal forest fires in Siberia and North America

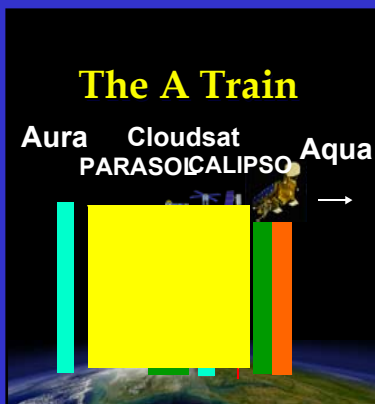


POTENTIALLY LARGE RESPONSE

- Melting of polar ice sheets and permafrost
- Decrease of snow albedo from soot deposition
- Efficient UV/Vis absorption by ozone, soot
- Halogen radical chemistry

UNIQUE OPPORTUNITY FOR NASA

- Large NASA satellite fleet for atmospheric composition and radiation
- Interagency and international collaboration through POLARCAT
- Broader synergies enabled by other IPY activities (OASIS for oceans, etc.)



ARCTAS STRATEGY: use aircraft to increase value of satellite data for models of arctic atmospheric composition and climate

Satellites: CALIPSO, OMI, TES, HIRDLS, MLS, MODIS, AIRS, MISR, MOPITT

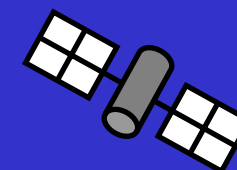
- Aerosol optical depth, properties
- CO, ozone, BrO, NO₂, HCHO

Aircraft: DC-8, J-31, B-200

- Detailed in situ chemical and aerosol measurements
- Remote sensing of ozone, aerosol, surface properties



Retrieval algorithm development
& validation
Correlative information
Model error characterization



Data assimilation
Diagnostic studies



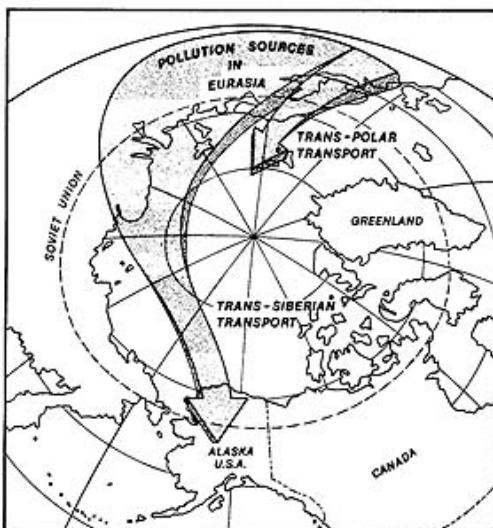
Models: CTMs, GCMs, ESMs

- Source-receptor relationships for Arctic pollution
- Effects of boreal forest fires
- Aerosol radiative forcing
- Arctic chemistry

Two 1-mo deployments: Mar-May and Jun-Jul 2008

ARCTAS Science Theme 1: winter/spring long-range transport of pollution to the Arctic

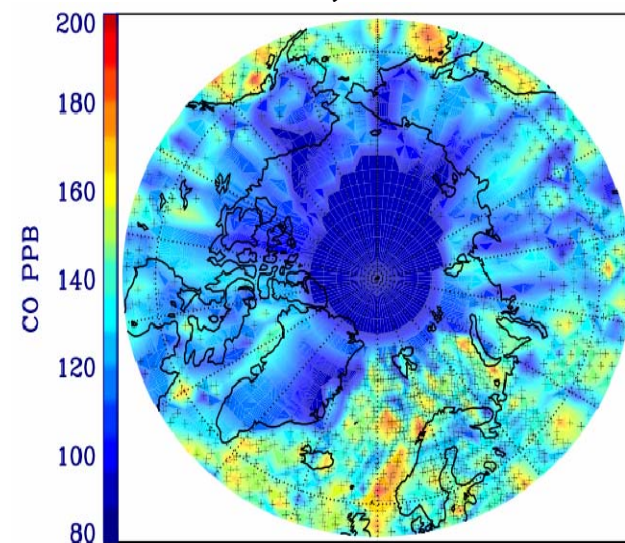
European influence



Arctic haze



TES 600 hPa CO, March 2006



J. Worden, JPL

- What are the transport pathways for different pollutants?
- What are the contributions from different source regions, the source-receptor relationships?
- What is the interannual variability (e.g., Arctic Oscillation)?

Satellite capabilities:

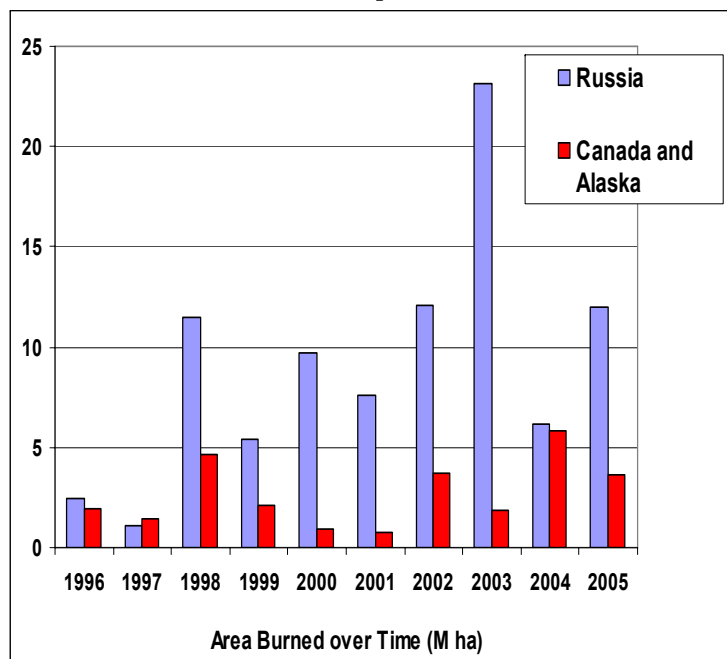
- CO (TES, AIRS, MOPITT)
- O₃ (TES, OMI-MLS)
- aerosol (CALIPSO, MODIS, MISR)

Aircraft added value:

- detailed chemical composition
- tracers of sources
- vertical information

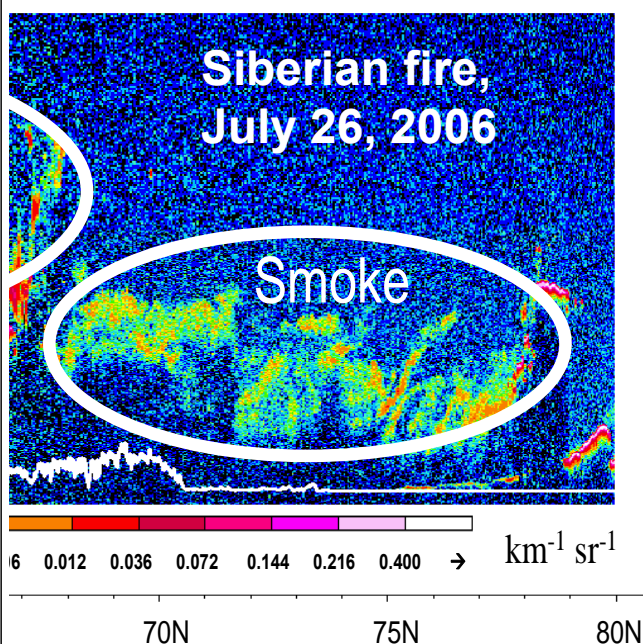
ARCTAS Science Theme 2: Boreal forest fires

Fire trend over past decade

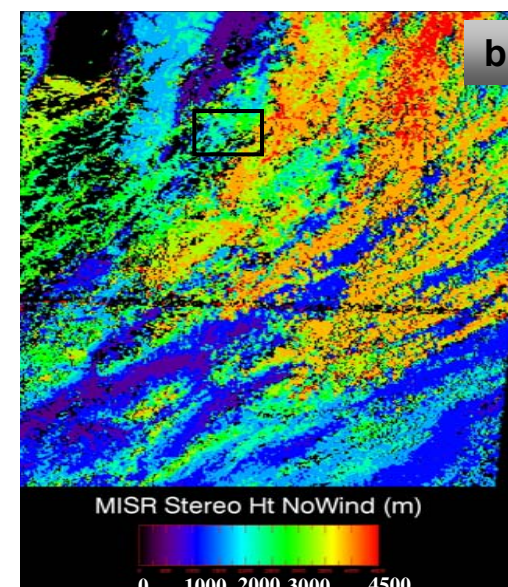


J. Crawford, LaRC

CALIPSO view of fire plume MISR injection height



C. Trepte, LaRC



R. Kahn, JPL

- What is the chemical composition & evolution of the fire plumes?
- What are their aerosol optical properties, how do these evolve?
- What are the injection heights, what are the implications for transport & chemistry?

Satellite capabilities:

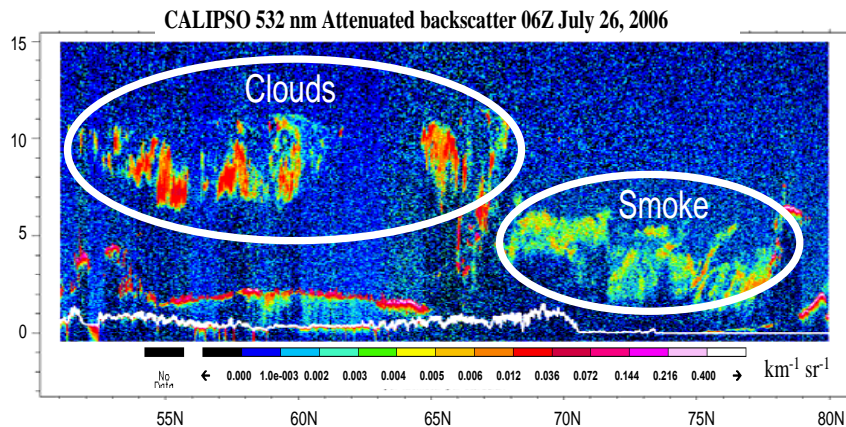
- plume layers (CALIPSO)
- injection heights (MISR)
- aerosols (OMI, MODIS, MISR)
- CO (TES, MLS, AIRS, MOPITT)

Aircraft added value:

- detailed chemical composition
- aerosol properties
- pyroconvective outflow

ARCTIC Science Theme 3: Aerosol radiative forcing

CALIPSO clouds and smoke



C. Trepte, LaRC

Arctic haze



MISR true-color fire plume



R. Kahn, JPL

- What is the regional radiative forcing from Arctic haze, fire plumes?
- How does this forcing evolve during plume aging?
- What are the major sources of soot to the Arctic?
- What is the effect of deposited soot on ice albedo?

Satellite capabilities:

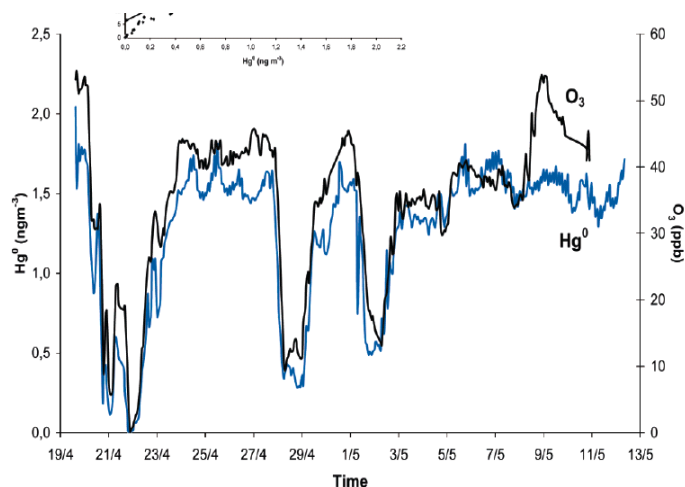
- UV/Vis/IR reflectances (Cloudsat, OMI, MODIS, MISR)
- multiangle sensing (MISR)
- lidar (CALIPSO)

Aircraft added value:

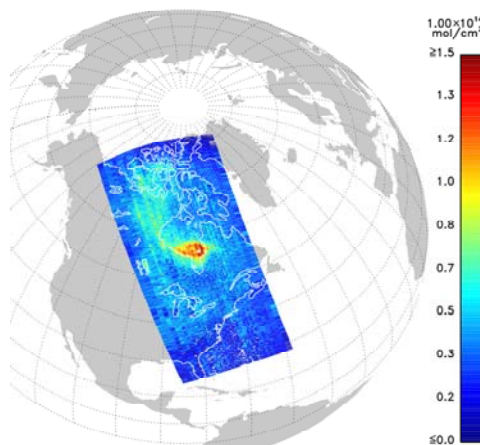
- detailed in situ aerosol characterization
- remote sensing of radiances, fluxes
- albedo and BRDF of surface

ARCTAS Science Theme 4: Chemical processes

Ozone, Hg depletion events OMI tropospheric BrO

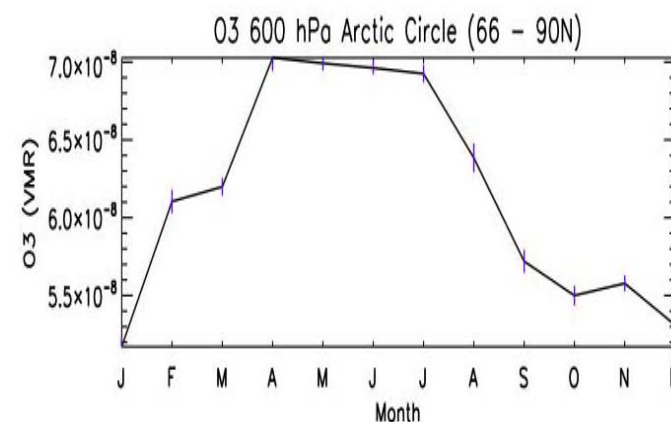


Sprovieri et al. [2005]



K. Chance, Harvard/SAO

TES tropospheric ozone



J. Worden, JPL

- What is the HO_x/NO_x chemistry in the Arctic?
- What drives halogen radical chemistry in the Arctic, what is its regional extent?
- What are the regional implications of halogen chemistry for ozone and mercury?
- How does stratosphere-troposphere exchange affect tropospheric ozone in the Arctic?

Satellite capabilities:

- Ozone (TES, OMI/MLS)
- BrO (IOMI)
- strat-trop exchange (HIRDLS)
- CO (TES, AIRS, MOPITT)

Aircraft added value:

- detailed chemical characterization, constraints on photochemical models
- validation of OMI tropospheric BrO
- HO_x measurement intercomparison

AIRCRAFT PLATFORMS, PAYLOADS



DC-8: major in situ platform

Ceiling 37 kft, range 4000 nmi, endurance 9 h

Payload: O_3 , H_2O , CO , CO_2 , CH_4 , NO_x and HO_x chemistry, BrO , halogen reservoirs, mercury, NMVOCs, halocarbons, SO_2 , HCN/CH_3CN , actinic fluxes, aerosol mass and number concentrations, aerosol physical and optical properties, remote ozone and aerosol



J-31: major aerosol remote sensing platform

Ceiling 26 kft, range 800 nmi, endurance 5 h

Payload: optical depth, radiative flux, radiance spectra

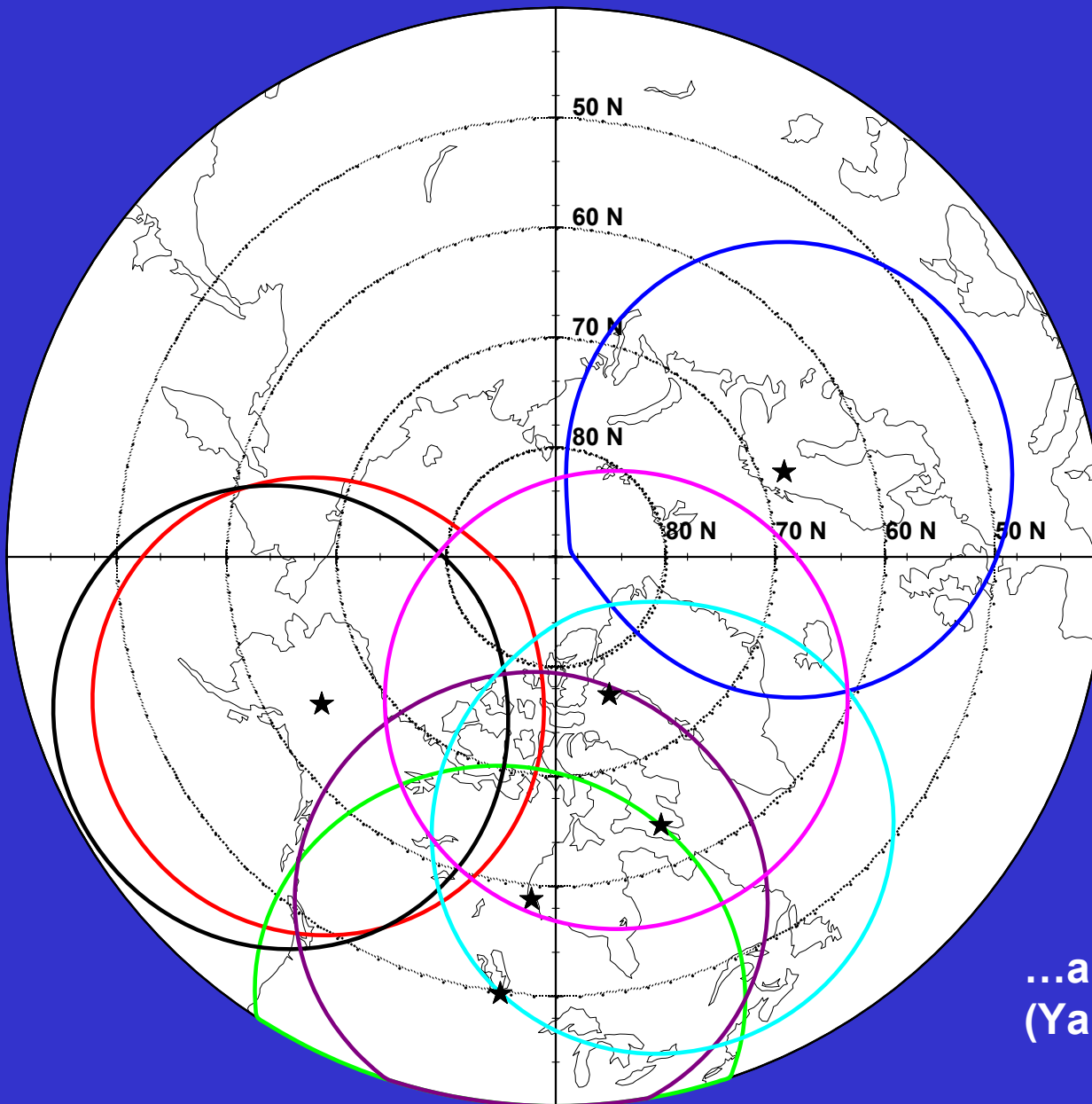


B-200: major CALIPSO validation platform

Ceiling 32 kft, range 800 nmi, endurance 3.5 h

Payload: High Spectral Resolution Lidar (HSRL)

POTENTIAL ARCTAS BASES AND NOMINAL DC-8 RANGES



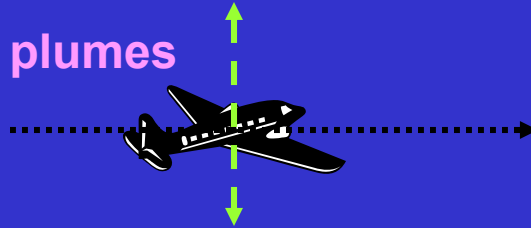
Anchorage
Fairbanks
Churchill
Winnipeg
Kiruna (spring)
Iqaluit
Thule

...also consider a Russian base
(Yakutsk?)

DC-8 FLIGHT STRATEGIES

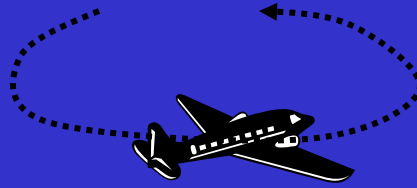
Lidar remote sensing:

- mapping of pollution plumes
- satellite validation



Process studies:

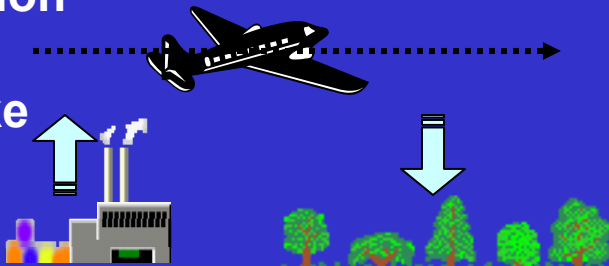
- photochemistry
- plume evolution
- transport mechanisms



Satellite validation

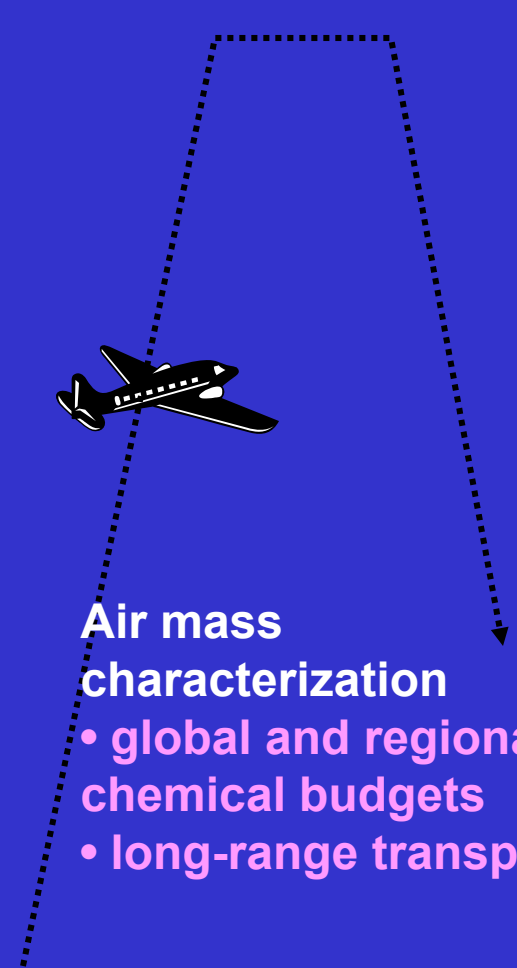


Characterization of emissions, surface uptake

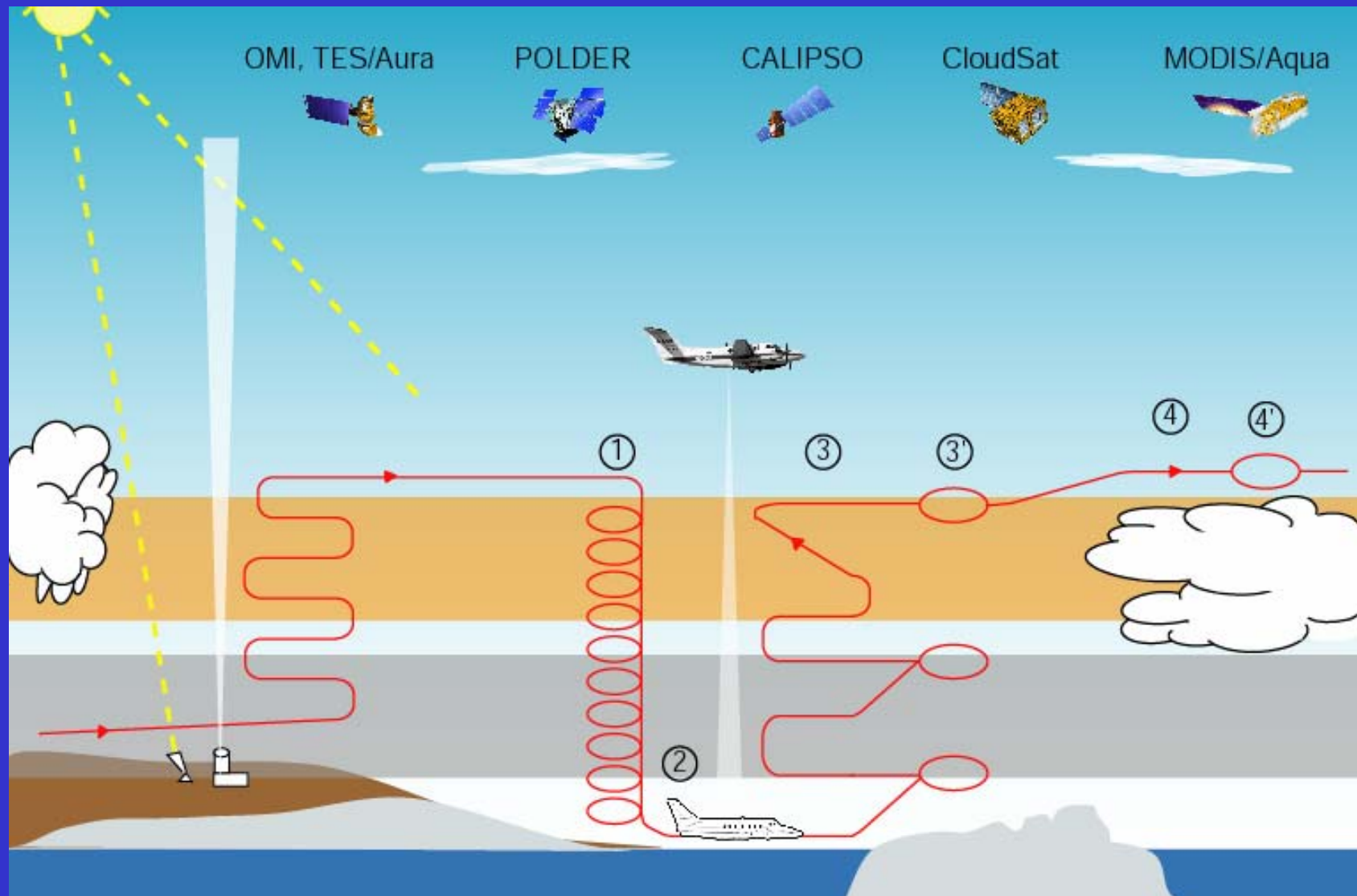


Air mass characterization

- global and regional chemical budgets
- long-range transport



J-31 FLIGHT STRATEGIES



MAJOR INTERAGENCY AND INTERNATIONAL PARTNERSHIPS UNDER POLARCAT

- **NSF/OPP+ATM:** summer surface chemistry intensive at Summit
- **DOE:** aircraft intensive at Alaska ARM site in April 08, focus on aerosol-cloud radiation
- **NOAA (not committed yet):** WP-3 based in Iqaluit and R/V Brown cruise to Greenland and Barents Seas, focus on aerosol-cloud interactions and North American export of pollution
- **DLR (likely, not committed yet):** Falcon based in NE Canada in summer 08, focus on pyroconvection and cirrus chemistry
- **Canada (pending):** three aircraft in summer 07 and 08 based in Yellowknife, focus on pyroconvection.